WEEKLY REPORT – SINDHUJA CHADUVULA

This report is to show multiple simulation runs with varying vehicle type parameters to study their impact on traffic behaviour.

Our simulation consists of various vehicle types(‘vType’) and traffic flows(‘flow’). These are parameters for SUMO simulations:
Two vehicle types are defined:
DEFAULT_VEHTYPE: A yellow vehicle with various characteristics.
EGO_VEHTYPE: A red vehicle with slightly different characteristics.

Four vehicle flows are defined which define the routes vehicles take within the simulation.

Flow_ID	Vehicle_Type	Begin Time(s)	End Time(s)	Starting Edge	Ending Edge	Vehicles Per Hour
f_0_default	DEFAULT_VEHTYPE	0.00	200.00	-E29	E31	600
f_1_default	DEFAULT_VEHTYPE	0.00	200.00	-E32	E30	600
f_0_ego	EGO_VEHTYPE	0.00	200.00	-E29	E31	600
F_1_edge	EGO_VEHTYPE	5.00	200.00	-E32	E30	600

The Flow Information Table describes traffic patterns in the simulation. Each row represents a unique vehicle flow, specifying the vehicle type, duration and frequency of the flow, and the starting and ending road segments for that flow.

For each vehicle type, specific attributes are varied

- For DEFAULT VEHTYPE, tau parameter is varied
- For EGO VEHTYPE, lcCooperative, collisionMinGapFactor, tau, sigmagap, sigmaerror are varied

SCENARIO 1: Studying about the mean and variance of each parameter that caused collision across the simulation when it is ran for multiple times

In this scenario, we study the collisions caused between the Default vehicle and the ego vehicle in a roundabout, where only one attribute in the simulation is changed at a time to check which parameter is causing the collision and each parameter is ran for five different times to observe the number of collisions caused each time.

The simulation ran each parameter(‘tau’, ’lcCooperative’, ‘collisionMinGapFactor’, ‘sigmagap’, ‘sigmaerror’) 5 times producing data that allows the computation of the mean and variance for each parameter value.

Mean – It represents the average value of the collision over the 5 runs.
Variance – It provides a measure of how spread out the number of collisions are around the mean. The square root of the variance gives the standard deviation.

Significance of Mean and Variance –

Mean - By calculating the average number of collisions for each parameter value, we get an idea of the "central" or "typical" value of the results. If a certain parameter value consistently results in a high average number of collisions, it might be indicative of a more unsafe traffic condition for that value.

Variance(and Standard Deviation) - Variance gives a sense of how spread out the numbers of collisions are around the mean. If the variance is high, it means that the number of collisions across the runs varies significantly from the average. A high standard deviation (root of variance) means that the number of collisions is spread out over a larger range of values, indicating inconsistency or unpredictability in the results.

Overall, by analyzing the mean and variance of the collisions for different parameter values, it provides insights into which parameters (and their values) have a consistent impact on traffic safety and which ones lead to more unpredictable outcomes.

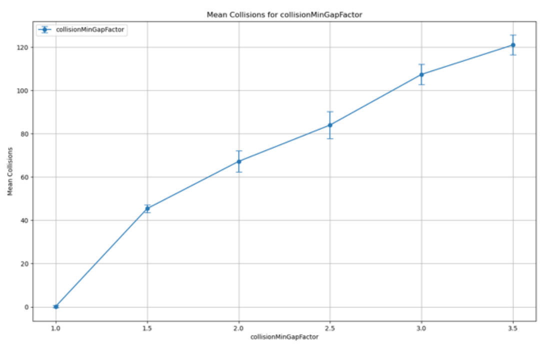
Outputs:

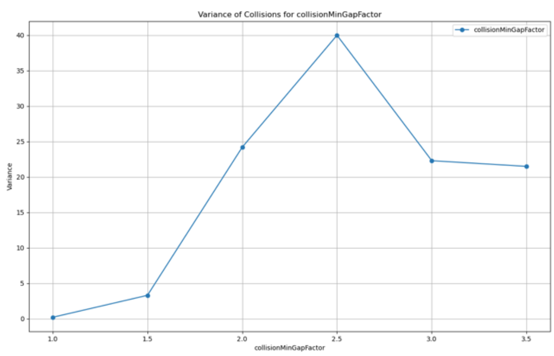
CollisionMinGapFactor:

The collisionMinGapFactor parameter typically represents a multiplicative factor applied to the minimum gap that a vehicle requires to avoid a collision. The "gap" can be understood as the minimum distance a vehicle tries to maintain from other vehicles to avoid collisions. several factors might contribute to this observed behavior

- Aggressive Driving Behaviour
- Unintended consequences in overtaking
- Higher Traffic Density

While increasing the collisionMinGapFactor might seem like a straightforward way to reduce collisions by keeping vehicles farther apart, the dynamics of traffic flow can be complex. The interaction of this factor with vehicle behavior, traffic density, and other simulation parameters can produce counterintuitive results. It underscores the importance of understanding not just individual parameters, but their interactions and the broader system dynamics when assessing traffic safety.





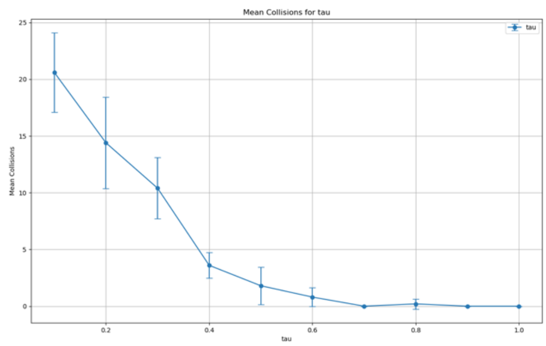
The variance measures the spread or dispersion of the data around the mean. A higher variance indicates that the data points tend to be more spread out from the mean, while a lower variance indicates that the data points are closer to the mean.

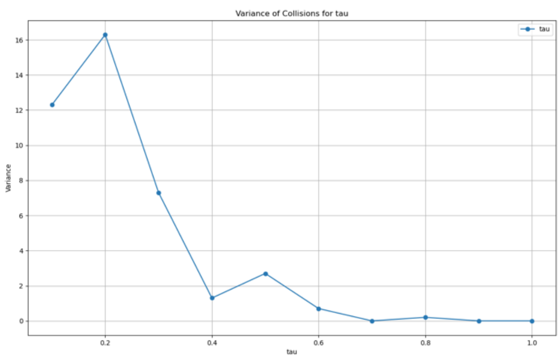
Tau:

The parameter tau typically represents the time headway or reaction time of a driver/vehicle in traffic simulations. Time headway is the time interval between the passage of the front end of one vehicle and the front end of the following vehicle, measured from the same point. Essentially, it dictates how quickly a driver reacts to changes in the driving environment.

- Sudden Braking or Swerving
- Increased Aggressiveness
- Flow Disruptions

while quick reaction times might seem advantageous, they can introduce unpredictability and aggressiveness into driving behaviors, leading to more collisions. A more realistic reaction time, represented by higher τ values, can lead to smoother and more predictable traffic flow, reducing the number of collisions.





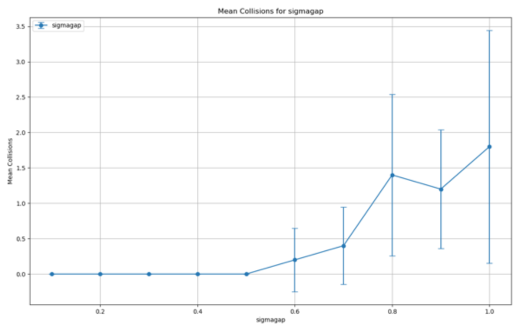
the high variance in collisions at $\tau=0.2$ indicates a region of the reaction time parameter where the traffic system's behavior is highly sensitive and variable. As τ increases, the system stabilizes, leading to more consistent and predictable outcomes, as reflected by the reduced variance.

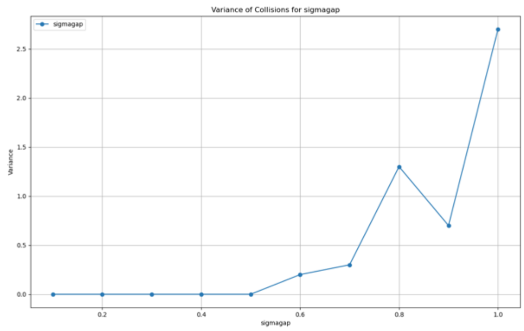
SigmaGap:

The parameter sigmagap often denotes the variability or randomness in the perception of safe time/headway gaps by vehicles. When referring to its influence on collisions in traffic simulations:

- Increased unpredictability at higher Sigma
- Difficulty in Gap Acceptance
- Stabilized Driving with Decreased Sigma

a higher sigmagap indicates greater variability in how drivers perceive safe distances from other vehicles. This increased variability can lead to more unpredictable and risky driving behaviors, resulting in a higher mean number of collisions.





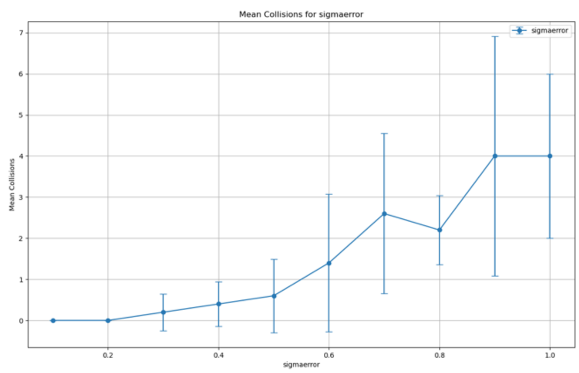
the increasing variance for sigmagap from 0 to 1, and particularly its high value at 1, highlights the unpredictability and inconsistency in traffic outcomes when drivers have high variability in their perception of safe gaps.

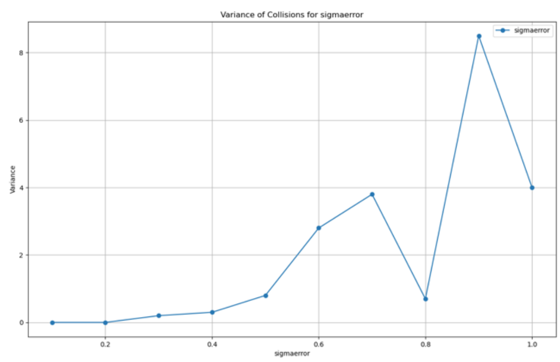
SigmaError:

In the context of the simulation, sigmaerror typically represents the standard deviation of a normal distribution used to generate random error values for some vehicle parameters. The higher the sigmaerror, the more uncertainty or randomness gets introduced into the system regarding the associated vehicle parameter.

- Increased perception errors at Higher Sigmaerror
- Inconsistent Driving Behaviour
- Variablility in Gap Acceptance

the trend suggests that as you introduce more randomness or unpredictability into the behavior of vehicles (via sigmaerror), you inherently increase the risk of collisions in the system. This observation aligns with real-world insights where unpredictable driving behaviors (due to factors like distracted driving, inebriation, etc.) increase the risk of traffic accidents.





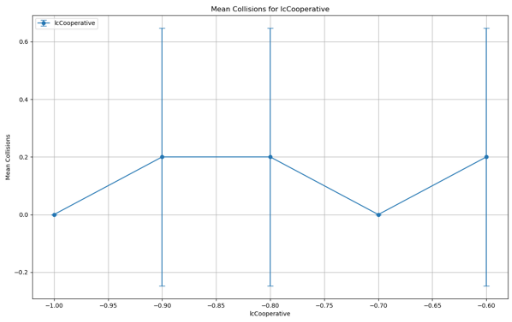
increasing sigmaerror leads to more collisions on average, but the consistency of these outcomes varies. The system becomes most unpredictable at around sigmaerror=0.9, but somewhat stabilizes at sigmaerror=1, even though the number of collisions remains high.

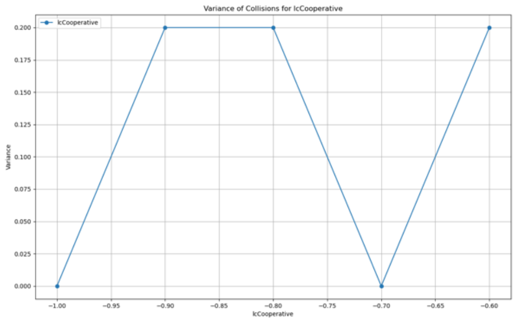
LcCooperative:

The parameter lcCooperative influences the cooperation level of vehicles during lane changing. A more negative value for lcCooperative means the vehicle will be less cooperative when it comes to lane changing and will behave more aggressively.

- Stable Collision Trend: Regardless of the varying levels of the lcCooperative parameter, the occurrence of only one collision each time indicates a certain level of stability or a consistent bottleneck point in the roundabout. This could be due to a specific traffic scenario that occurs irrespective of the cooperative behavior.

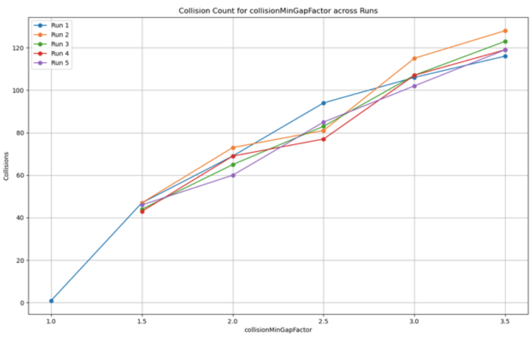
The observed consistency in collision means across the given lcCooperative range suggests that within these specific values, the variations in lane-changing cooperation don't have a significant differential impact on the number of collisions in the current simulation setup.

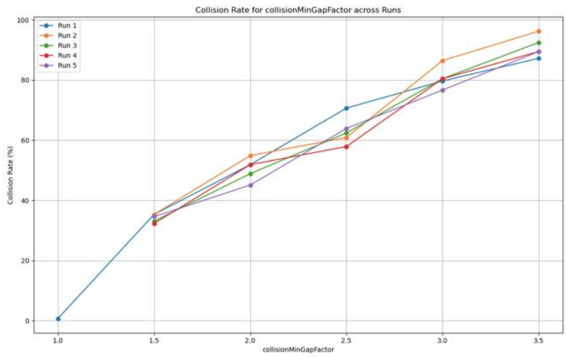




Collision Counts and Collision Rate for different parameters for multiple runs:

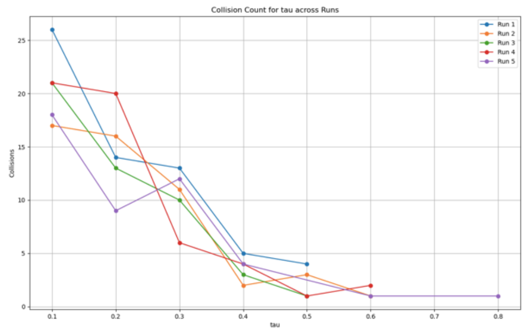
CollisionMinGapFactor:
Increasing the collisionMinGapFactor reduces the gap at which a collision is detected, making the system more susceptible to recording collisions, especially if other factors (like driver behavior or traffic density) remain constant. It's a direct indication of the importance of maintaining safe following distances in traffic systems. The gradual increase in both collision count and rate highlights the compounded effect of reducing safety margins in traffic simulations.

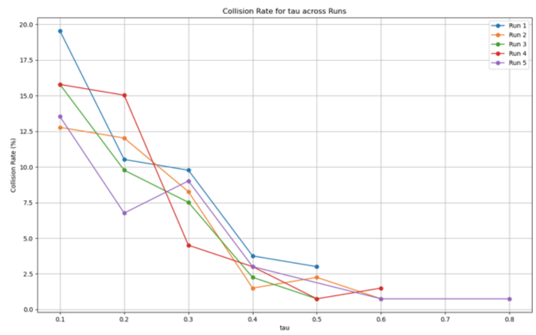




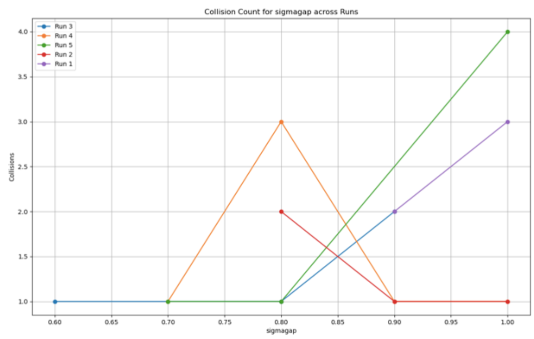
Tau:
Increasing the tau parameter, or the reaction time, appears to have a stabilizing effect on the simulation's traffic flow. The drivers' increased time to react provides more room for error and adjustment, leading to a reduction in both collision count and rate. This observation

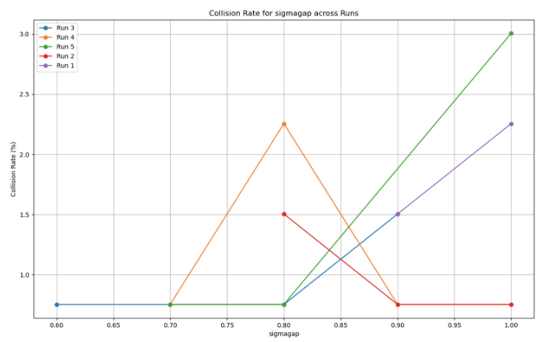
underscores the importance of drivers being attentive and having adequate time to react to changes in traffic conditions to prevent collisions.



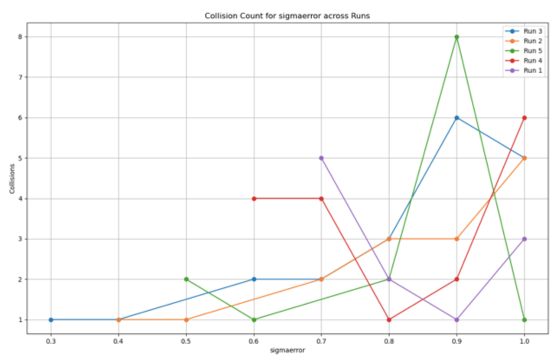


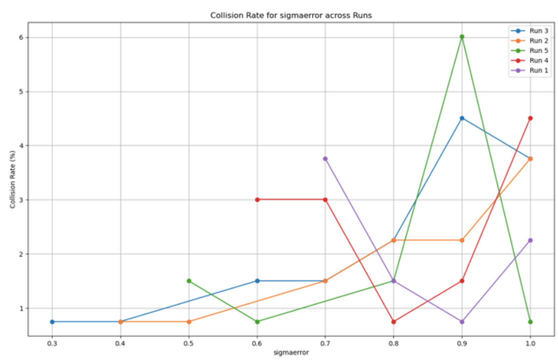
SigmaGap:
The variability in collision count and rate as sigmagap increases can be attributed to the growing unpredictability and variability in driver behaviors. The broader range of time headway preferences might lead to a mix of conservative and aggressive driving styles, leading to an inconsistent pattern in collisions. It's essential to consider both the intrinsic properties of the sigmagap parameter and the external factors of the simulation when analyzing and interpreting these results.





SigmaError:
The effects of increasing sigmaerror on collision count and collision rate are multifaceted and can be influenced by intrinsic factors related to driver behavior and external conditions of the simulation. The variability in outcomes across runs underscores the complex interplay of estimation errors, adaptive behavior, and other driving parameters. Understanding these effects requires careful analysis of each run's specific conditions and the broader implications of driver estimation errors in traffic flow.





SCENARIO 2: Comparative Traffic Dynamics of four distinct driving behaviors across two routes.

Four Distinct Driving Behaviors:
Passive Drivers : Embodying a safety-first approach, passive drivers consistently adhere to lower speed limits and prioritize keeping a substantial gap between themselves and the car ahead. Their cautious nature stems from a blend of moderate acceleration and deceleration patterns coupled with a deliberate reaction time, ensuring they avoid hasty decisions on the road.

Aggressive Drivers: With a penchant for speed and quick decision-making, aggressive drivers often maintain high velocities and are unafraid to tailgate or stay in close proximity to the car in front of them. Their swift acceleration and near-instantaneous reaction times underscore a confident, albeit potentially risky, driving style that can lead to rapid maneuvers in traffic.

Tailgaters: Despite adhering to moderate speeds, tailgaters are notably distinguished by their habit of closely following vehicles ahead, almost as if tethered. This behavior, driven by a combination of short following distances and quick reaction times, implies an assertive approach, potentially making other drivers feel pressured.

Speeders: Reveling in the thrill of high speeds, speeders, however, exhibit a contrasting duality in their driving style. While they rapidly accelerate to achieve their desired velocity, they maintain a significant buffer distance from the vehicle ahead. This juxtaposition, coupled with a more leisurely reaction time, suggests a desire for open roads and an aversion to densely packed traffic scenarios.

Attributes that are varied
maxSpeed - The maximum speed (in m/s) the vehicle is allowed to travel. This is the top speed a vehicle can reach under ideal conditions.
acel - The acceleration ability (in m/s^2) of the vehicle. It describes how quickly the vehicle can increase its speed.
decel - The deceleration ability (in m/s^2) of the vehicle. It indicates how quickly the vehicle can decrease its speed or come to a stop.
minGap - The minimum distance (in meters) the vehicle tries to maintain with the vehicle in front of it under normal driving conditions.
tau - The reaction time (in seconds) of the driver/vehicle. It's the time the driver takes to react to changes in the traffic environment.
color: Specifies the RGB (Red, Green, Blue) values for the vehicle's visual representation in the simulation.

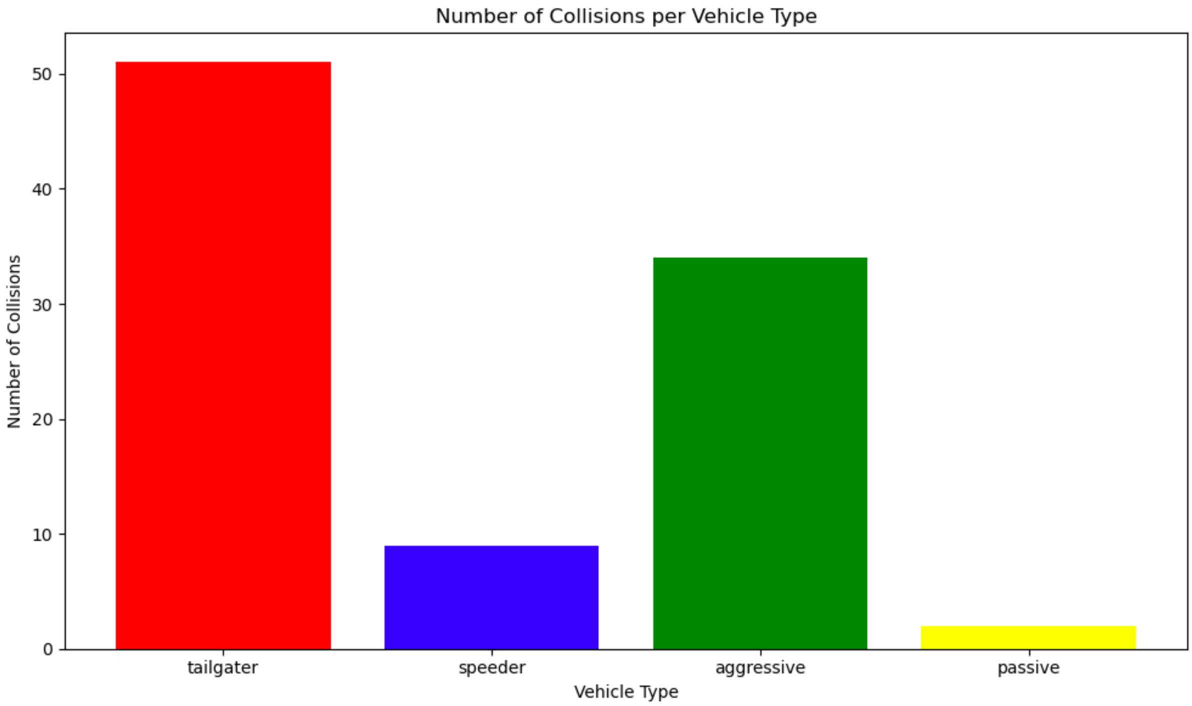


Image shows number of collisions caused by each vehicle type and among the four tailgater vehicles are causing most of the collisions.